

Lens on climate change

Using place-based learning to explore climate change effects

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CONTENT AREA

Earth science

GRADE LEVEL

6-12

BIG IDEA/UNIT

Climate change

ESSENTIAL PRE-EXISTING KNOWLEDGE

None

TIME REQUIRED

5-7 weeks if integrated with other class work, but modifications described only take a few class periods

COST

None, if students' phone cameras and free software are used

SAFETY

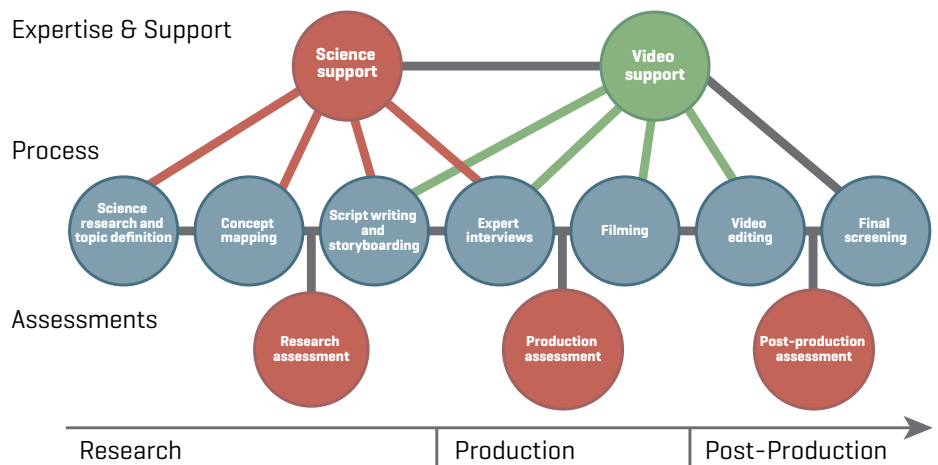
None

In this article, we describe a student-driven approach to learning and communicating about climate change, in which students create a short, documentary-style film about environmental changes in their community. This approach combines science learning with engaging storytelling and artistic elements, which makes it appealing and accessible to different types of learners. We find that through filmmaking, students gain a deeper understanding of climate science and strengthen their ability to collaborate with peers. Students also learn that cli-

mate change is a complex topic, and that it is difficult to predict how climate change will affect our society.

The science research and film production process is divided into three phases; Figure 1 provides tasks, goals, and assessment suggestions for each. A final film screening event offers students the opportunity to share and discuss their work with others, and it has been a highlight of our program. This approach has been successfully implemented as a class project and in after-school clubs (see Figure 2).

FIGURE 1 Science research and film production phases with tasks



Selecting a topic and researching film styles

Engage

As students are introduced to the project and the idea of filmmaking, showing them thought-provoking, short films about climate change, including student-produced films (see Resources) can help to inspire students' thinking. After showing these film examples, have students brainstorm the ways they experience the impacts of climate change in their lives; most students will be more engaged if they can personally relate to the topic. Prior knowledge and personal interests can be assessed and connect-

ed to climate change during this brainstorming process. For example, some students may know about the atmosphere and its composition, and other students might have hobbies such as hunting or skiing. Initial brainstorming may be done either with the whole class or in small groups. As a guiding question, ask students if they are aware of any local impacts of climate change or any local mitigation strategies (e.g., solar panels, lawn watering restrictions).

Explore

As students begin to develop their topics, they will need a

foundation of climate science knowledge. As a short introduction or refresher, the teacher can connect prior knowledge with new information and introduce important scientific terms and vocabulary. *Climate Literacy* (USGCRP 2009) provides a comprehensive overview of the basics of climate science. Further guidance on teaching these basic concepts can also be found on the Climate Literacy and Energy Awareness Network (CLEAN) website (see Resources). Showing a basic overview film about the Earth's energy balance or the role of greenhouse gases can also provide a sufficient basis for student knowledge (see "Steroids,

FIGURE 2: Time suggestions for student-led film production

Deliverable	Hours of in-class activities [estimated]	Hours of out-of-class activities [estimated]	Out-of-class activity
Topic selection	1-2	0.5	Watch sample videos
Questions for experts	1-2		
Research summary	1-2	1	Research topic and write short constructed response
Takeaway message	1		
Script/treatment	1-3	1	
Storyboard	1-3	1	Complete storyboard outside of class
Interviews [shoot]	1 per interview	0.5	
B-roll [shoot]	2-5	0.5	
Voice-overs/additional footage [shoot/collect]	>1		
Rough cut	3-4	2	Out-of-class editing
Revision cut	2	1	Out-of-class editing
Add title credits/music	2	0.5	Add titles and credits
Final cut	4	2	Out-of-class editing

FIGURE 3: Example topics for student-produced films

Topic	Local/societal impacts	Expert interviews
Water availability	<ul style="list-style-type: none"> • Effects on local agriculture • Effects on municipal water systems 	<ul style="list-style-type: none"> • Farmer/rancher • Water manager • Climatologist/hydrologist • Community members
Extreme weather events and climate	<ul style="list-style-type: none"> • City emergency planning • Susceptibility to extreme events 	<ul style="list-style-type: none"> • Climatologist/meteorologist • Emergency responders • City planners and managers
Energy production and climate	<ul style="list-style-type: none"> • Local energy sources • Personal energy use • Climate impacts of energy sources 	<ul style="list-style-type: none"> • Energy engineers • Climatologist • Renewable energy researcher • Community members

Baseball, and Climate Change” in Resources). Developing key concepts using graphic organizers such as word walls makes the concepts visual and establishes a useful reference for student use throughout the unit. Hands-on lessons on related topics, such as the behavior of molecules in the atmosphere, the effect of glacial melt on sea levels, or how soil absorption of precipitation affects crop growth, can also help students connect local events with global patterns (see Resources).

Equipped with a basic understanding of the climate system, student groups then research local impacts of climate change as they select their topic. Groups work best when they contain four to six students. With groups of this size, each student is able to actively participate by taking a specific role in the science research, the film

production team (e.g., filming, editing, interviewing, directing), or multiple roles. All students, however, should participate in the science research to ensure their learning of the underlying science concepts. The addition of artistic film elements such as music or student artwork has helped our English language learners and others fully participate.

If students are new to independent research, they may need direction from the teacher to help them decide on a topic and pursue their research (e.g., through a list of potential topics or links to authoritative websites and credible data sources; see Figure 3). Steps that can help students identify their film topics include:

1. group brainstorming,
2. web research from trusted sources,

3. a review of local news sources or other resources, and
4. bringing in local experts to present on topics.

One challenge of building climate science content knowledge through topics focused on local outcomes lies in the global scope of many existing climate resources. Websites for local, state, or national government agencies often provide good starting points for exploring issues that are affecting communities (see Resources). Introductory exercises during which students connect an activity or interest of theirs with climate change (e.g., fishing and changes in stream volumes) can give students a starting point from which to begin their research. Students are also encouraged to write the definitions of scientific terms where they can be saved and viewed by all group members to support building a shared topical vocabulary.

Teacher guidance

Teachers must define the type and amount of scientific information students should use (e.g., films must include scientific data to back up claims, sources must be cited). Depending on the topic and the group, the research phase may take five to 15 hours, with some research assigned as homework (see Figure 2 for example time budget). It is helpful to show videos from scientific agencies such as NASA that demonstrate entertaining and accurate scientific communication (see Resources)

and provide examples of appropriate use of humor in a documentary film. Teachers should also provide guidance about the expected film length. For in-class projects, a film length of one to five minutes is ideal. Longer productions may require substantial work to be done outside of class. It is also important to define the expected time budget for each step. A realistic time budget will help students be efficient (see Figure 2 for example time budget). Teachers should also decide what types of films are acceptable. For example, will films need to follow a documentary style? May humorous or fictional elements be included? Humor can be an effective tool when communicating topics such as climate change, but teachers should discuss with students the appropriate role and boundaries of humor in their films. Students will likely want to create a short segment of bloopers to capture the funny moments that occur during filming, although it is up to the teacher whether to include them in the final film.

Outlining the film: Concept mapping, scripting, story boarding, and interviewing experts

Explain

Student groups discuss their selected climate change topics and identify the data and interpretations that underlie current scientific understanding of those topics.

Each group can report out to the class to practice talking about their topic. Drawing on their research, students also discuss the potential impacts of climate change on their community and possible mitigation steps. To structure their discussions about the science content, student groups build their own concept map (Figure 4). *Concept maps* help students organize their ideas and visualize how they will use those ideas in their film. Concept maps also help students identify places where additional research is needed. Additionally, it is helpful to provide students with guiding questions, such as:

1. What scientific information is necessary to explain your topic?

2. In which ways does your topic affect our community?
3. Who are the local experts who could provide a community perspective on your topic?

Interviews with local experts can help students answer open scientific questions and expose them to alternative perspectives on their topic (see Figure 3 for examples).

Elaborate

After students complete the first draft of their concept map, they present it to another student group or the whole class, explaining their ideas. Presenting their topic to others and answering questions from peers checks

FIGURE 4: Student-produced concept map around the topic of flooding

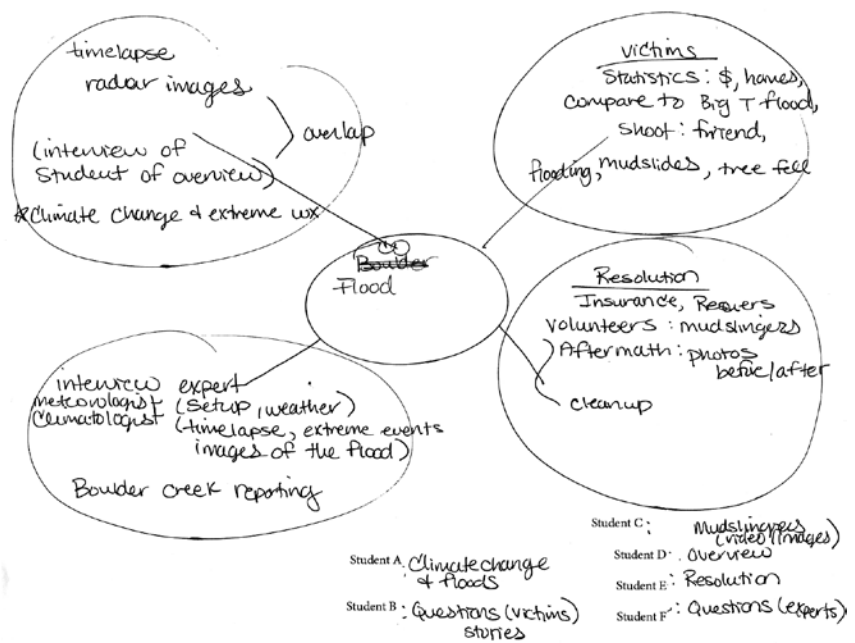
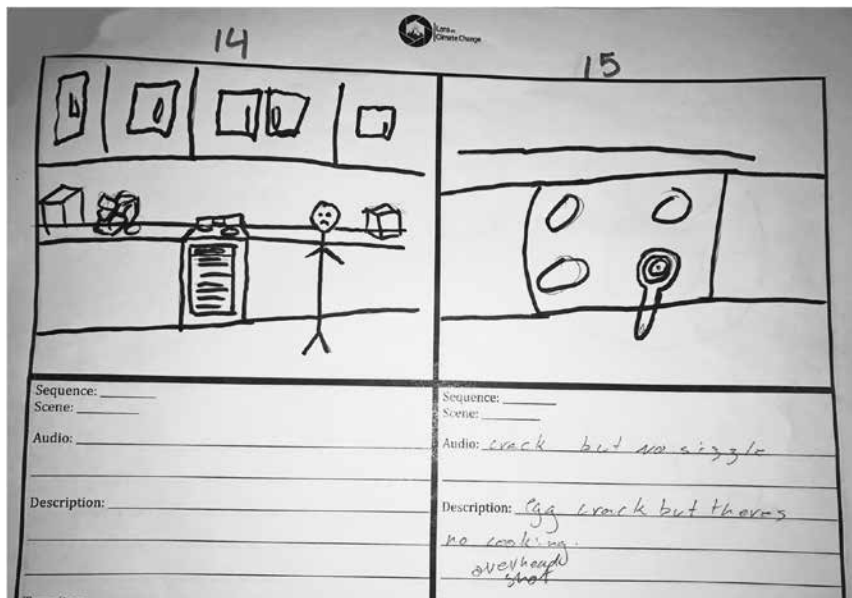


FIGURE 5: Example topics for student-produced films



students' understanding of the science behind their topic and scientific terms. This process also helps students identify their own unanswered questions. At this point, students should revise their concept maps.

As students refine their scientific ideas, they identify the message they want to deliver and the target audience for their film, such as their peers or the city council. Students can then summarize their film's message into three sentences or less highlighting the film's purpose, takeaway message, and audience. The concept mapping helps students develop this synthesis. With their overall message in mind, students can decide on their story narrative and write a film script based on their revised concept map. Scripts outline the film plot and are written in prose with characters, dialogue, and setting.

The final step of the research phase is the development of a storyboard from the script (Figure 5). A *storyboard* is a sequence of drawings with directions (e.g., camera placement notations and indications of character movement) and dialogue. Each cell in a storyboard represents one shot in a film and should include a drawing of the characters and their actions. Cells can be numbered to organize the order of the shots in the video. Storyboards help students stay organized throughout film production and editing and help them stick with their scientific message (see Online Supplemental Materials for storyboard template and storyboard rubric).

Research assessment

Each student writes a short, constructive response to a scientific

topic-specific prompt (see Tankersley 2007). Prompts are individual to each video group. For example, a group covering the impact of drought on agriculture would respond to a prompt asking about the impact drought has on crop production. Students must differentiate science fact from opinion and find multiple reliable resources (see Online Supplemental Materials for rubric).

Production

Filming and interviewing

Depending on the topic and the film genre students pursue, films may incorporate a mix of elements such as narration, expert interview footage, student-recorded footage of local landscapes or places, existing footage or still images, and animation. Storyboards provide a useful guide as students record their footage. Students are encouraged to organize their film files in shared folders (e.g., Google Drive). High-quality footage can be captured with cell phones, tablets, and most still cameras. Interviews with scientists increase students' understanding of climate science. Local experts (e.g., state climatologist, scientists from a local research institute) can be invited to the school for interviews or can be interviewed remotely through Google Hangouts, Skype, or other virtual connections. The virtual interview can be recorded through screen capture software or integrated recording options. Some science organizations offer other opportunities to virtually

connect with scientists for student interviews (see Resources).

Implementation tips

Access to equipment is different for every school, but we emphasize creative ways to convey ideas or scenes with available classroom resources. Student groups can acquire film elements in various ways: through field trips to collect footage at sites away from their schools, creating whiteboard animations and drawings to depict situations that cannot be obtained through direct filming, and writing short skits that are acted out to convey ideas (see Resources). We suggest talking with students about appropriate filming locations (e.g., public spaces) and restrictions on other locations (e.g., private property without owner's consent).

Production phase assessment

The assessment should be provided to students at the beginning of the production phase to guide their work. Based on their film narrative, student groups write 10 to 20 science-based expert interview questions and rank them in order of their importance. Students then complete a practice interview within their group prior to interviewing their expert, including a proper handshake, making eye contact, and using the phrase, "I do not understand; can you please rephrase your response?" As part of the practice interview, students should also set up the camera and

review the recording to ensure they have the technology mastered (e.g., interview subject is in frame and in focus, and their voice is audible and clear).

Postproduction

Editing

During the postproduction phase, students assemble their footage into their finished film. Students can save time by shooting their films in sequential order, but postproduction editing is required for complete and coherent products. Editing can be done using free, intuitive software packages (see Resources for suggestions). Most editing software has three basic components—a bin, a time line, and a viewer (see Online Supplemental Materials). The *bin* shows all the footage from the camera but can also be used to hold other footage or still images. The *time line* is a display of all video and audio tracks in the film. Students select footage from their bin and drag it to the timeline to arrange their film. The *viewer* shows the final film based on the timeline.

Evaluate

Students create a *rough cut* of their film by ordering the best clips from each scene according to their storyboard. Students then share the rough cuts with other groups or the whole class for feedback and constructive critique. Students use guiding questions (addressing science message and presentation) when watching and critiquing the

rough cuts of other groups:

- What is the main message of the film?
- Is the science clear and well communicated?
- What was your favorite part of the film?
- Why were certain production decisions made (e.g., graphics, interview footage, humor)?

Students are guided to frame feedback in a positive and constructive way. The teacher should model how to provide constructive feedback and help students phrase their feedback in positive, helpful ways. Students then use their peers' feedback to create a *final cut* of their films. Edits could include changing the order of scenes, cutting scenes, or adding clarifying information such as text, images, and graphics. During the creation of the final cut, students add elements such as titles, credits, music, and sound effects (see Resources).

The final film screening is a capstone event, as it gives students the opportunity to share their work with their peers and community. A screening event can occur in many venues—in class, during a school assembly, or at a local library. Many environmental or climate-focused film festivals across the country also accept student-produced films; a simple web search can provide information on local film festivals. These events garner wider recog-

dition for students, allow them to speak publicly about a science topic they became “experts” in, and let them involve their parents and interested members of the public. The screening event also provides a rigid deadline for production. Students may want to share their films on social media or video sharing sites; however, students must have media releases from everyone in the films prior to sharing them publicly, and supplemental footage and music must be public domain to avoid copyright issues (*Tip: Advanced browser search options allow you to search only for freely available images or footage*).

Implementation tips

In our implementation, films were screened in a public event. We only provided a short introduction and then handed the floor to students to allow them to answer questions and interact with the audience. Each film was shown twice. After the initial presentation, students were invited to briefly discuss their climate change topic and production experience before each film was shown a second time.

Postproduction assessment

Final student films are assessed using a rubric (see Online Supplemental Materials).

Scaling the model to your classroom

Many other media formats can

be used to scaffold science learning. These formats tend to share a similar production sequence. Media projects can range from a short, single-class-period activity or homework assignment to a semester-long capstone project. Our full implementation takes about two or three weeks for the research phase and three or four weeks for the production and postproduction stages, if these are integrated with other class work. Science teachers can collaborate with art, photography, or technology teachers or media specialists to broaden expertise and increase student support for the film component. Some alternative media formats are: short video blogs (*vlogs*), combinations of video, still images, and supporting text; *public service announcements*, short, engaging video messages about a topic of public interest; *visual storytelling*, a series of still images edited together, with or without text or other graphic overlays, to convey a scientific concept; and video *mash-ups*, syntheses of scientific topics using an original script that draws on visuals found online rather than new footage (see Resources for public domain images, audio, and footage).

Implementation feedback

Through this activity, students acquire a deeper understanding of climate science in general and their topic in particular. Learning gains are achieved through research of the topic and formu-

lating the interview questions, as well as being active listeners and answering follow-up questions from their classmates and audience. Students learn that science research is not a step-by-step procedure, because critical thinking and questioning are necessary to gain a solid understanding of the overall concept.

In our postprogram evaluation surveys, students described challenges they faced throughout the program. Common challenges included:

1. difficulty generating ideas for their film and selecting a topic,
2. keeping the team focused and on-task throughout the project, and
3. managing time during production and completing their film within the allotted time.

We addressed these challenges by offering example topics to student groups that struggled with ideas for their films. Time management was addressed by dividing the project into production steps and defined daily milestones. The model presented here helps keep students focused and on-task when learning about climate science and throughout film production through step-by-step procedures and regular assessments at each phase. Figure 6 shows student tasks for an example film production.

Overall, student feedback suggested that the self-directed learning format was inspiring and trans-

FIGURE 6: Film production process used by a group of Colorado middle and high school students

Nederland’s Own: Arapaho Glacier [5:08 min.] <http://youtu.be/-bZNzB19jj>

Stage	Description
Research	Students from the Nederland Middle/Senior High School learned through research that their Colorado community’s drinking supply comes from the nearby Arapaho Glacier. The water supply is threatened by annual decreases in glacier mass due to a changing climate. No students were aware of their drinking water source before conducting this research, so they identified local experts who would be able to provide further information.
Film production	Students interviewed a glaciologist from the University of Colorado and a local water manager to learn more about the Arapaho Glacier and the drinking water supply. They further interviewed fellow students and community members to ask them about the glacier; none of these interviewees knew about Nederland’s drinking water source. Students collected additional footage for the film by going on a hike in the mountains behind the school to view the glacier and record B-roll footage. Students also recorded a virtual Google Earth tour showing the locations of their school and the glacier. They also collected old images of the glacier from the local public library.
Postproduction	Students framed the film with the Google Earth tour. They interspersed interview snippets and narration over their B-roll images. They added a title, music, captions, and credits. They also produced a short trailer that included some bloopers. Their film was shown to the entire school during an assembly and at a local film festival.

formational. Specifically, students commented that the program made them more aware of climate impacts in their communities and inspired them to make changes in their daily lives to reduce fossil fuel consumption. ●

ACKNOWLEDGMENT

The work described in this article was funded by the National Science Foundation [award #1513320].

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RESOURCES

Films

Bright Lights in the Bakken—<https://youtu.be/qLq2x7YPv0s>

Climate Shorts playlist—<http://bit.ly/2rolZTH>

Student-produced films—<http://cires.colorado.edu/outreach/media/lccc/old-videos>; https://cleanet.org/cced_media/cam_tv/index.html

Climate change impacts nationwide: Starting places for research

CLEAN—<http://cleanet.org>

EPA Climate Change Indicators 2016—www.epa.gov/climate-indicators#explore

Global Climate Change: Vital Signs of a Planet—<http://climate.nasa.gov/effects>

National Climate Assessment—<http://nca2014.globalchange.gov>

Teaching about climate change

Steroids, baseball, and climate change—www.youtube.com/watch?v=MW3b8jSX7ec

Organizations that virtually connect with scientists

Climate Voices—<http://climatevoices.org/about>

Learn More About Climate—<http://learnmoreaboutclimate.colorado.edu>

B-roll and free films

Freesound [public domain sound effects and music]—www.freesound.org

Pond5 [public domain footage]—www.pond5.com/free

Public Domain 101—<https://youtu.be/Nc3Dnh2JCMl>

Video production resources

Editing basics—<https://vimeo.com/blog/post/video-101-editing-basics>

Intro to storyboarding—<https://vimeo.com/17451230>

Mac iMovie tutorial—<https://youtu.be/GKu5p4e4CbY>

Shooting basics—<https://vimeo.com/17853099>

Windows Movie Maker tutorial—www.youtube.com/watch?v=JNKRCaiox4E

More information on alternative media formats

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Media literacy as a pathway to bridge the digital and STEM divides: Interest driven media projects for teachers in the trenches. In *Improving K-12 STEM education outcomes through technological integration*, ed. by M. Urban and D. Falvo, 23–43. Hershey, PA: IGI Global. <http://cires.colorado.edu/outreach/LOCC>.

ONLINE SUPPLEMENTAL MATERIALS

Assessment rubrics, editing software components—www.nsta.org/Scope1710

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Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

Standard

MS-ESS-3: Earth and Human Activity

www.nextgenscience.org/dci-arrangement/ms-ess3-earth-and-human-activity

Performance Expectation

MS-SS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

DIMENSIONS	CLASSROOM CONNECTIONS
<p>Science and Engineering Practices</p>	
<p>Asking Questions and Defining Problems Obtaining, Evaluating and Communicating Information</p>	<p>Students brainstorm and research the impact climate change has on their lives.</p> <p>Students write interview questions targeted at a science expert who can provide a community perspective on their climate change topic.</p> <p>Students create a film about their climate change topic.</p>
<p>Disciplinary Core Idea</p>	
<p>ESS3.D: Global Climate Change</p> <ul style="list-style-type: none"> • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to climate changes depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. 	<p>Students use their research to discuss the potential impacts of climate change on their community and describe possible mitigation steps.</p>
<p>Crosscutting Concept</p>	
<p>Cause and Effect</p>	<p>Students create concept maps that show how their selected climate change topic impacts the local community.</p>